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Department of Plant Pathology

EXPERIMENTS IN THE DUSTING AND SPRAYING OF APPLES

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By F M BLODGETT
Fellow in Plant Pathology

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Ithaca, New York, November 28, 1913.

ACTING DIRECTOR W. A. STOCKING, *College of Agriculture, Ithaca, New York:*

Dear Sir: I beg to submit herewith a report of work done under the Herman Frasch Industrial Fellowship, with the recommendation that it be published as Experiment Station Bulletin 340.

The work has been performed by F. M. Blodgett, Fellow, and represents investigations extending through the years 1911, 1912, and 1913. In 1911 the work was done in the orchard of William Smith, Albion, New York; in 1912 in the orchard of Lee Kinne, Hartwick Seminary, New York; and in 1913 in the orchards of E. W. Catchpole & Sons, North Rose, New York, and H. T. Lawson, Owego, New York. Special acknowledgment is due these men for their hearty cooperation in placing their orchards at our disposal and in liberally aiding the investigations in every possible way.

Valuable assistance in various technical details of the experiments has been rendered by Professors Crosby and Herrick, of the Department of Entomology at this University, Dr. T. J. Headlee of the New Jersey Agricultural Experiment Station, F. H. Pough of the Union Sulphur Company, New York City, and R. G. Harris, formerly with the Vreeland Chemical Company, New Brunswick, New Jersey. The materials used in 1913 were kindly furnished by the Union Sulphur Company and the Vreeland Chemical Company, and the dusting machines by the Kansas City Dust Sprayer Manufacturing Company.

Respectfully submitted,

DONALD REDDICK,
Professor of Plant Pathology.

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EXPERIMENTS IN THE DUSTING AND SPRAYING OF APPLES

F. M. Blodgett

(*Received for publication November 29, 1913*)

INTRODUCTORY

Apple-growers in New York are confronted constantly with new problems or with the recurrence of old problems. Not the least of these, either in number or in severity, are the diseases and the pests that ravage orchards. In fact, there are many growers who regard the control of pests and diseases as the limiting factor in the successful production of apples. Constant vigilance and repeated spraying must be practiced every year if first-class fruit is to be obtained. Wallace (1911) records a case — which at least two thousand New York fruit-growers saw for themselves — in which a block of trees in an orchard, generally conceded to receive as good care and as intelligent and careful treatment as any in the State, was left unsprayed for a single season, with the result that at picking time ninety-eight per cent of the fruit was scabby.

Orchardists very generally recognize the fact that the apple-scab disease is epidemic in nature, and that in epidemic years they are not nearly always successful in controlling it. Some of the essential factors in the successful control of orchard diseases were outlined by Reddick (1913) in an address before the New York State Fruit Growers' Association at Rochester in January, 1913. The most important factor emphasized in that address, and one that has received altogether too little attention, is the time element. The interrelation of bud development with the development of the scab fungus, and the relation of these to meteorological conditions — particularly the occurrence of rainfall — is set forth; and it is shown that for Baldwins and Rhode Island Greenings throughout western New York, the actual time limit in which effective spraying for scab could be done was on two occasions — the blossom cluster spray and the calyx spray — both in 1911 and in 1912, confined to four days. In the same address it is stated that very few men are in a position to spray their orchards thoroughly in so short a time. In general it may be said that New York apple-growers are awakening to the fact that they may make all the applications of spray usually recommended for the orchard

(1911) Wallace, Errett. Lime-sulfur as a summer spray. Cornell Univ. Agr. Exp. Sta. Bul. 289:142.

(1913) Reddick, Donald. Factors influencing successful orchard spraying. New York State Fruit Growers' Assoc. Rept. **1913**:51–54.

and still have scabby fruit. Many growers appreciate that their spraying equipment is insufficient, and would be glad to supplement it if there were any assurance that they could have enough men and teams to operate additional equipment.

The realization by growers of their inability to fight diseases and insects in epidemic years, and the knowledge of the fact that this is due in the main to their inability because of physical limitations to make applications of spray at the proper time, has awakened much interest in the popular accounts of dusting which have appeared from time to time in the agricultural press. The extraordinary claims made for the dry method certainly appeal strongly to the grower who appreciates the importance of applications of preventives at critical times.

It is claimed for the dust method that the time of application is not limited by conditions of soil, inasmuch as the lightness of the outfit permits its transportation in the orchard at all times; that trees in rough or hilly ground, or in localities remote from a satisfactory water supply, may be protected without unusual difficulty; that the expense is less than for liquid spraying, since the handling of a large bulk of water is eliminated, the trees are covered more rapidly, the outfit is less expensive, and the operators are fewer in number. The claim for the dust method which has appealed most strongly to the writer is the fact that such large areas may be covered in a short time; some operators have claimed to be able to dust thirty to fifty acres of orchard per day. The cost of preparing the dust mixture has not always received consideration; but, even should it be considerably more expensive than the liquid, the great saving in time and the ability to cover large areas at critical periods in a minimum of time would largely offset the added cost of the dust.

In spite of the claims made by enthusiasts from time to time for the dusting of orchards, the results of carefully planned experiments by members of experiment stations have never proved favorable for this method.

HISTORICAL

Some experimenters — Walker (1906), Close (1905, 1906), Farrand (1905) — succeeded in controlling the codling moth as well, or nearly as

(1905) Close, C. P. Dust spraying in Delaware. Delaware Agr. Exp. Sta. Bul. 69:1–7.
(1905) Farrand, T. A. Report of South Haven Sub-station for 1904. Michigan Agr. Exp. Sta. Spec. bul. 30:474–475.
(1906) Walker, Ernest. Suggestions upon the care of apple orchards. Arkansas Agr. Exp. Sta. Bul. 91:166–168, 205–206.
(1906) Close, C. P. Dust and liquid spraying. Delaware Agr. Exp. Sta. Bul. 72:1–22.
(1906) Close, C. P. Third report on dust and liquid spraying. Delaware Agr. Exp. Sta. Bul. 76:1–19.

well, with the dust as with liquid sprays. Crandall (1906), Blair (1907), and Pickett (1908) give reports of the work done in Illinois, which was principally on the control of scab and bitter rot.

Crandall (1906) has presented the summary of conclusions reached as a result of the three-years experiments carried out in Illinois in the following words:

" Trees sprayed with liquid bordeaux and paris green retained their foliage in healthy working condition throughout the season. Dust-sprayed and check trees may be placed together because the behavior of foliage was the same in both. Leaves began falling in July and, in early September, these trees were practically denuded. This loss of foliage by dust-sprayed and check trees was due to apple scab, against which disease the dust spray was entirely ineffective.

" Differences in fruit were as marked as were differences in foliage. Liquid-sprayed trees give smooth fruit of good size. Dust-sprayed and check trees gave small ill-formed fruit, badly marked by scab and of very little value even as evaporator stock.

" Dust-spray is 52 per cent cheaper than liquid spray and it is easier to transport about the orchard. It has no other advantage.

" The results of the experiments are sufficiently decisive to warrant the conclusion that dust-spray is absolutely ineffective as a preventive of injury from prevailing orchard fungi, and that it is considerably less efficient as an insect remedy than is the liquid method of applying arsenites."

Among others who have carried out experiments is Faurot (1908), who reports experiments in Missouri resulting in four to five per cent scab-free fruit obtained by dusting with dry bordeaux as compared with ninety per cent obtained by spraying with liquid bordeaux. Lawrence (1906), in Washington, had equally poor results. Garman (1908) cites work in Oregon almost equally decisive. Craig (1904) sums up as follows some cooperative work carried out under his direction in New York State: " The labor and expense of applying dust sprays appear to be less than for sprays in liquid form. Six applications of dust spray were practically

(1904) Craig, John. The dust spray. Cornell Univ. Agr. Exp. Sta. Bul. 216:111–119.
(1906) Crandall, Charles S. Spraying apples. Relative merits of liquid and dust applications. Illinois Agr. Exp. Sta. Bul. 106:207–242.
(1906) Lawrence, W. H. Apple scab in eastern Washington. Washington Agr. Exp. Sta. Bul. 75:1–14.
(1907) Blair, Joseph C. Bitter rot of apples. Illinois Agr. Exp. Sta. Bul. 117:529.
(1907) Blair, J. C. Fruit and orchard investigations. Illinois Agr. Exp. Sta. Circ. 107:40–45.
(1908) Pickett, B. S. Spraying apple orchards for insects and fungi. Illinois Agr. Exp. Sta. Circ. 120:15–16.
(1908) Faurot, F. W. Spraying versus dusting. Missouri Fruit Sta. Bul. 19:1–24.
(1908) Garman, H. Apple orchard pests in Kentucky. Kentucky Agr. Exp. Sta. Bul. 133:66, 70–71.

not more effective on apples than two applications of bordeaux mixture; neither did they cost more." In these experiments the apples were graded as firsts, seconds, thirds, and so on, with no definite data on the control of apple scab.

Materials used in the above experiments

In all these experiments some form of the so-called "dry bordeaux" was used. In some of the experiments, the commercial preparation sold by the Dust Sprayer Manufacturing Company, of Kansas City, Missouri, was used, and in others a mixture was made up for the work. One of the commoner home-prepared mixtures is described by Waite (1906) as being composed of copper sulfate 4 pounds, quicklime 4 pounds, air-slaked lime 60 pounds. In other cases sal soda, caustic soda, and various other ingredients were included; but in all cases the essential fungicidal ingredient was some form of copper and the insecticidal agent was the well-known paris green. The extensive experiments performed seem to leave little doubt that a dry mixture containing copper as the fungicide is ineffective against our most important apple disease, scab, although dry paris green has in some instances proved effective against the chief insect enemy, codling moth.

CONSIDERATIONS LEADING TO INCEPTION OF THE PRESENT WORK

With the advent of lime-sulfur solution as an effective fungicide for the control of apple scab, the question arose as to what is the active agent in this case. Suggestions were first made as to what the active insecticidal agent is. Haywood (1907) writes: "From the decomposition of the wash there are obtained sulphur in a very finely divided form, thiosulphate for a time, and sulphite which is gradually set free. The writer is of the opinion that these are the active agents in killing insects." Haywood also gives the following decomposition products for lime-sulfur wash as determined by spraying filter papers and making analyses at stated intervals, in some cases spraying the papers with water in order to simulate dew:

TABLE 1. COMPOSITION OF DRY LIME-SULFUR-SALT WASH AFTER STANDING (EXPRESSED IN GRAMS PER 100 CUBIC CENTIMETERS OF SOLUTION)

	Samples not watered				
Time of standing	Free sulfur	Sulfur as thiosulfates	Sulfur as sulfites	Sulfur as sulfates	Total sulfur
5 days	1.71	1.97	0.11	0.01	3.80
5 days	1.72	1.97	0.10	0.01	3.80
8 days	1.74	1.94	0.14	0.01	3.83
8 days	1.77	1.94	0.12	0.02	3.85

(1906) Waite, M. B. Fungicides and their use in preventing diseases of fruits. U. S. Agr. Dept. Farmers' bul. 243:11.

(1907) Haywood, J. K. The lime-sulphur-salt wash and its substitutes. U. S. Chem. Bur. Bul. 101:21.

TABLE I (*continued*)

Samples watered in order to simulate dew					
Time of standing	Free sulfur	Sulfur as thiosulfates	Sulfur as sulfites	Sulfur as sulfates	Total sulfur
10 days	1.94	1.66	0.22	.....	3.82
10 days	1.93	1.69	0.20	.....	3.82
4 weeks	2.11	1.42	0.29	0.15	3.97
4 weeks	2.13	1.41	0.27	0.16	3.97

From this table it may be seen that a considerable proportion of the lime-sulfur applied soon became free sulfur, and that the longer it remained on the filter papers, these being watered so as to simulate dew, the more sulfur was set free.

Similarly there has been question as to just which of these substances may be active fungicidal agents. Van Slyke and others (1910) made the following statement. "What specific compounds are directly responsible for the effects produced we are not yet certain. It is held, as the result of some experimental work, that the effect of the lime-sulphur mixture is not due to the direct action of calcium pentasulphide (CaS_5) or of calcium tetrasulphide (CaS_4), but is due rather to compounds that are formed from these, either calcium thiosulphate (CaS_2O_3), or free sulphur, or both." Wallace and others (1911) found that the sulfite and sulfate of calcium showed little fungicidal value. In the bulletin cited (page 181), results of using lime-sulfur solution precipitated with carbon dioxid are reported. The action of carbon dioxid on lime-sulfur solution alone would undoubtedly yield principally free sulfur and some hydrogen sulfid which, by the time the spray mixture was dried on the slides, would disappear or break down to form additional free sulfur. The fact, then, that this precipitated sulfur mixed with calcium carbonate had nearly as much fungicidal value as the original solution sprayed on the slides would seem to indicate that the fine sulfur had considerable fungicidal value. Apple and peach trees sprayed with this precipitated lime-sulfur bore out the laboratory observations on its effectiveness as a fungicide. It should be remembered, however, that sulfur deposited on the leaf from the drying of lime-sulfur solution, or that thrown down as a precipitate by carbon dioxid, is in a very fine state of division.

Aside from the known value of sulfur in the control of surface mildews, it has also been used in a mechanical mixture known as Scott's self-boiled

(1910) Van Slyke, L. L., Bosworth, A. W., and Hedges, C. C. Chemical investigation of best conditions for making the lime-sulphur wash. New York (Geneva) Agr. Exp. Sta. Bul. 329:432.

(1911) Wallace, E., Blodgett, F. M., and Hesler, L. R. Studies of the fungicidal value of lime-sulfur preparations. Cornell Univ. Agr. Exp. Sta. Bul. 290:192–193.

lime-sulfur which is principally a suspension of lime and sulfur. This is reported by Scott and Quaintance (1911) as giving uniformly good results on peaches for the control of brown rot and scab. It has been fairly effective on apples for the control of scab, but not so effective as lime-sulfur solution.

It is to be noted that, although considerably more sulfur is present in this spray than in lime-sulfur solution, the sulfur is not nearly so finely divided, especially when commercial flour is used. It was therefore thought worth while to test a very finely ground flour sulfur for the control of apple scab, both as a liquid spray and as a dry application. From the experience of the writer (1913) with mixtures of lime and sulfur in the control of hop mildew, it was thought desirable to use only pure sulfur and arsenate of lead, and later, if diluents seemed necessary from the point of view of expense, to use something that would not combine with the oxidation products of sulfur. Accordingly a very finely ground sulfur was used. In Plate XIII, Figs. 1 to 4, are shown respectively the ordinary flour sulfur, flowers of sulfur, the finely ground flour sulfur used in the present experiments, and sulfur precipitated by drying on a glass slide from lime-sulfur solution. It may be clearly seen that the sulfur used in the present experiments was much finer than the ordinary flour sulfur or even the flowers of sulfur, and compared favorably in fineness with that deposited by lime-sulfur solution. It was therefore hoped that if this finely ground sulfur were applied in sufficient quantity it would control the scab of apples, thus obtaining the advantages claimed for dusting and at the same time eliminating all tendency to injure foliage.

The injurious effects of lime-sulfur solution when applied to potato, grape, peach, and raspberry foliage are well known. Aside from a positive injury sometimes found on apple foliage, there is the further question as to whether a dwarfing effect does not occur under certain conditions.

EXPERIMENTS OF 1911

The first experiments with the use of dry sulfur to replace lime-sulfur solution were made by the writer in 1911. A number of different mixtures were applied in the form of dust in that year; but the work of the season was without results as far as the control of scab or of insects was concerned, since there were not enough of these pests in the orchard where the test was made to give any results as to their control. It was very noticeable, however, that the mixtures adhered remarkably well to the foliage and the fruit of the trees, and that there was no indication of foliage injury or dwarfing.

(1911) Scott, W. M., and Quaintance, A. L. Spraying peaches for the control of brown-rot, scab, and curculio. U. S. Agr. Dept. Farmers' bul. 440:21–40.

(1913) Blodgett, F. M. Hop mildew. Cornell Univ. Agr. Exp. Sta. Bul. 328: 298–299.

EXPERIMENTS OF 1912

During the following year the experiments were continued on a small scale. Instead of the hand machine used in the previous year, a traction machine was employed. This machine was not entirely satisfactory for use in an orchard. It was of the type used by the writer in the hop fields, in the experiments already mentioned, and since it was driven from the wheels it could not be stopped at the individual trees in order that a thorough application might be made. This was approximately accomplished, however, by making several trips around the rows of trees.

The whole orchard was sprayed once in the spring just as the buds were bursting (May 1), with lime-sulfur solution of dormant strength. The separate plats were afterward sprayed or dusted three times, on the following dates: May 15 to 16, May 31 to June 1, June 15.

The trees included in this experiment were principally Rhode Island Greenings and Northern Spies. Some of them were sprayed with lime-sulfur solution and lead arsenate; to others a dry mixture of flowers of sulfur and arsenate of lead was applied; to others sulfur and arsenate of lead were applied in suspension in water; and still others were left unsprayed. In this orchard very little apple scab developed either on the fruit or on the leaves of any of the trees, so that complete records were not made. However, in order that some indication might be obtained as to the degree of insect control secured and the control of what little scab there was, one tree of Rhode Island Greening apples from each block was picked and the apples were counted. The results of the counts are given in the following table:

TABLE 2. A CLASSIFICATION OF THE PICKED RHODE ISLAND GREENING APPLES FROM THE KINNE ORCHARD, HARTWICK SEMINARY, NEW YORK

Material used	Total number of apples	Sound		Unsound		Apple scab		Bud moth		Codling moth				Curculio		Aphis and red bug	
										Calyx entrance		Side entrance					
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	399	15	3.8	384	96.2	37	9.3	23	5.8	148	37.1	55	13.8	292	73.2	17	4.3
Suspension of sulfur[1] and lead arsenate 1–50	2,890	2,383	82.5	507	17.5	3	0.1	90	3.1	98	3.4	143	4.9	122	4.2	88	3.0
Lime-sulfur 1–40 and lead arsenate 1–50[2]	689	507	73.6	182	26.4	5	0.7	21	3.0	39	5.7	39	5.7	36	5.2	61	8.9
Dry flowers of sulfur 10 and lead arsenate 1	2,554	2,201	86.2	353	13.8	13	0.5	41	1.6	32	1.3	120	4.7	153	6.0	5	0.2

[1] In diluting this mixture, 2 gallons of a paste made of approximately 50 per cent water and 50 per cent finely ground sulfur was used to 50 gallons of water.

[2] The arsenate of lead used in these experiments was in the dry form. This would be equivalent to about 2 pounds of lead arsenate in paste form.

While in the above table only a relatively small number of apples are considered, yet the figures may be taken as giving some indication of the comparative value of the different treatments. It will be noted that on the unsprayed part of the orchard the percentage of scabby apples was only a little over nine. This mild attack of scab seemed to be controlled about equally well by the three different treatments used. The effectiveness of arsenate of lead seems to have been about equal when applied with the lime-sulfur solution and with the suspension of sulfur, as would of course be expected. In the dry mixture it seems to have been considerably more effective than in either of the liquid mixtures.

In so far, then, as could be judged from this year's experiments, the results were very favorable for the dust preparation.

EXPERIMENTS OF 1913

Although two years had passed with few results obtained on the control of scab by the use of a dust preparation, and although there was comparatively little scabby fruit in 1912, there seemed to be some prospect for results in 1913. The scab situation was summed up by Reddick (1913) as follows: "One might be tempted to conclude that 1913 will be a repetition of 1912 so far as scab is concerned. This is not so certain. This year we have made careful observations of the new infections occurring in August and September, and find that, while the fruit has rarely been attacked, a considerable number of new infections occurred on the foliage, and in some cases leaves have been found which were completely covered with the fungus. . . . . If favorable rains occur and at the right time, there is every reason to expect a liberal sprinkling of scab in most orchards of the State next year."

With the prospect of more extensive scab infection in another year it was decided to continue the work in 1913 on a larger scale. Incidentally, a movement inaugurated to perform similar experiments in other States on a uniform plan afforded the advice and suggestions of a number of pathologists and entomologists in planning the experiments of the year. The selection and arrangement of plats was designed so as to eliminate as far as possible all experimental error. In brief, it was hoped to determine by these experiments the effectiveness of a dust mixture containing twenty per cent of dry powdered arsenate of lead and eighty per cent of finely divided sulfur, and of a paste — to be applied with water as a carrier — made up of free finely divided sulfur and arsenate of lead with a small quantity of a colloidal substance to aid in wetting the sulfur and the better to keep the sulfur and lead arsenate in suspension, as compared with the standard lime-sulfur solution with arsenate of lead and with an unsprayed check.

(1913) Reddick, Donald. Apple scab situation. West. New York Hort. Soc. Proc. 58: 86–89.

The arrangement of the variously treated plats can be seen from the accompanying diagrams. Each plat of trees was to be sprayed in the dormant state if necessary, and the individual plats were then to receive during the summer the treatments indicated below. It was planned tentatively to make four summer applications, following as closely as possible the general scheme of orchard treatment developed by various pathologists and entomologists in the State and fully detailed by Wallace (1913) in his monographic treatment of the apple-scab disease. All the treatments were to be made on the same day, however, or at least the difference in time of treatment was to be as small as possible and infection periods of the scab fungus were not to intervene between the treatment of the various plats. In determining the date of application the development of foliage and fruit, development of the scab fungus and of insects, and occurrence of general storm periods were to be followed closely, and an effort was to be made to apply the preparations before the arrival of the prolonged rains that frequently accompany such storm periods. The plats were to be treated as follows:

Plat 1. Commercial lime-sulfur solution diluted $2\frac{1}{2}$-100, and powdered arsenate of lead 2-100.

Plat 2. Finely ground sulfur [3] and powdered lead arsenate, mixed in the proportion of one part of lead arsenate [4] to four parts of sulfur; the quantity of mixture applied per acre to be 50 pounds (40 pounds of sulfur, 10 pounds of arsenate of lead).

Plat 3. Check. No summer treatment whatever.

Plat 4. To be sprayed with a paste containing the same materials as were used in plat 2, applied with water as a carrier at the rate of 14 pounds of paste (containing approximately 60 per cent dry sulfur) to 50 gallons of water to which $1\frac{3}{4}$ pound of powdered arsenate of lead was to be added just prior to use; the total application per acre to be approximately 300 gallons (equivalent to 40 pounds of sulfur, 10 pounds of arsenate of lead, per acre).

Owing to peculiarities of the season the schedule of applications usually recommended was not followed exactly, and because of unforeseen physical difficulties the quantities applied per acre were not always in accordance with the plan.

Details as to quantities of material used, dates of application and conditions influencing the same, time required, comparative costs, results, and methods of recording data, will be given in connection with the individual experiments.

[3] The sulfur was so finely ground that at least 95 per cent would pass through a 200-mesh sieve. The method of testing sulfur is described by the writer in Bulletin 328 of the Cornell University Agricultural Experiment Station.

[4] It will be remembered that a mixture containing one part of arsenate of lead to nine parts of sulfur apparently gave satisfactory control of insects in the experiments of 1912. Inasmuch as the fungicidal value of the sulfur seemed to be the important consideration, it was thought desirable to use an insecticide somewhat in excess this year in order that no possible insect pests might interfere with the work.

(1913) Wallace, Errett. Scab disease of apples. Cornell Univ. Agr. Exp. Sta. Bul. 335: 545–624.

Experiments in Catchpole orchard at North Rose

The experimental orchard at North Rose consisted of a block of Rhode Island Greening trees, seven rows wide and seventeen rows long, with other apples on three sides as shown in Fig. 17. One or two rows of other

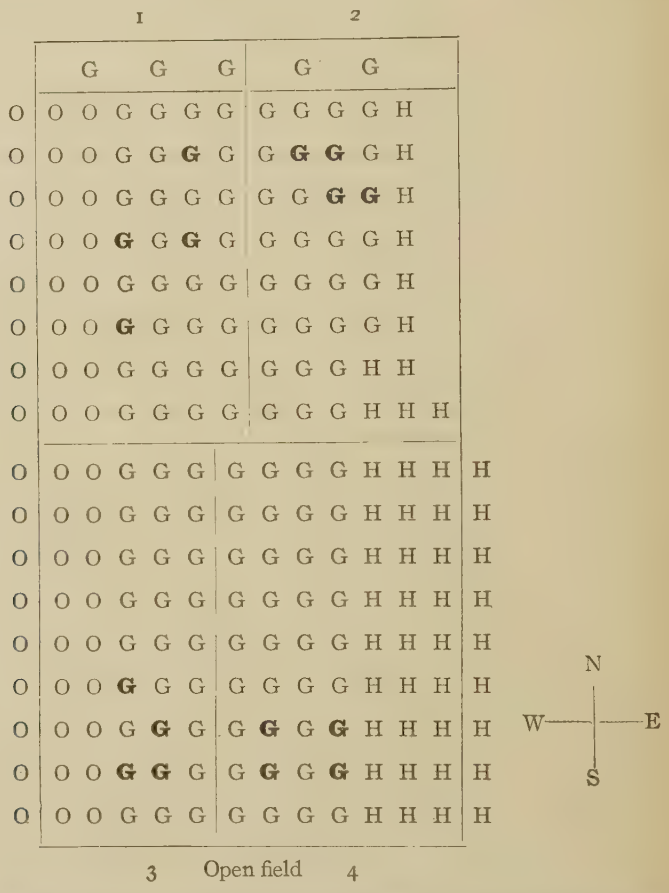

FIG. 17.— *Chart showing plan of the experiment performed in the Catchpole orchard, North Rose, New York. The Rhode Island Greening trees (G) enclosed in the black lines represent trees from which the commercial yield was determined, and the trees indicated by bold-faced type are the trees from which the apples were counted. G, Rhode Island Greening; H, Hubbardston; O, Oldenburg*

varieties were included in the plats in order to make them wide enough to leave an area of count trees in the center protected from migration of insects from surrounding plats by trees sprayed in the same way. The bold-faced letters on the map indicate count trees. These were chosen because of similar location, and were trees of about equal size and con-

dition of growth. The plats were made large enough so that usually it was not necessary to use adjacent trees for counting, although this was necessary in some cases.

The block included approximately 126 trees, about twenty years of age, planted 33 by 33 feet apart. The orchard had been cultivated between the rows, with an uncultivated part directly under the trees which was mulched. The orchard is mostly level, but has a ravine running into it on the center of the east side. It will be noticed that the count trees are at the opposite ends of the plat, so that none of them were in this low

FIG. 18.— *Dusting outfit in operation. Pen sketch from a photograph*

place. The trees at the top of the bank in the south end of the dust block were not thrifty because the topsoil, which was sandy, had been blown away. These were also avoided as count trees, as may be seen.

Methods and materials used

The liquid mixtures used in this orchard were applied with a power spraying outfit carrying a pressure of 120 to 140 pounds, with three men and three horses for its operation. The dust mixture was applied with a large power outfit (Fig. 18) manufactured by the Dust Sprayer Manufacturing Company, Kansas City, Missouri, operated by a 1½-horse-power "New

Way " gasoline engine. This engine caused considerable difficulty in the work because it was not large enough. A dormant spray of winter-strength lime-sulfur solution was applied to the entire block. Three summer applications were made with each of the different preparations tried: the first just before the blossom buds opened, the second when the petals were about one half off, the third four weeks later. The last application was delayed because codling moths appeared very late this year. In Table 3 are shown the dates, amounts of spray material used, and other data, for the different applications.

The cost figures given in the table are calculated on the basis of horse labor at 10 cents per hour, man labor at 20 cents per hour, lime-sulfur solution at 14 cents per gallon, dry arsenate of lead at 18 cents per pound, and sulfur at $2.10 per hundred. Of course these figures are more or less arbitrary. The cost of the deterioration of the machine is not taken into account. At the above figures the diluted lime-sulfur mixture would be worth 98 cents per 100 gallons, the paste 92 cents per 100 gallons (this does not include cost of preparation), and the dry mixture $5.28 per 100 pounds.[5]

It will be noticed that in the first application of the dry mixture nearly twice as much of the mixture was used as in either of the succeeding applications. This was largely due to difficulty with the engine, which stopped frequently or ran so slowly that much material was wasted in trying to make a satisfactory application. It is doubtful whether the first application was any more thorough than either of the succeeding ones, the surplus quantity of the mixture being largely wasted. The last two applications were made with less waste of time; but there is good reason to believe that even these applications could have been made with less material and in a shorter time if the engine had been large enough to run the machine steadily and at a slightly higher speed.

It will be noticed that although the cost of application of the dust mixture was considerably less than the cost of application of the liquid mixture, the cost of the mixture itself was very high in comparison with that of the liquid mixture. This may be attributed to two causes, namely, the large quantity of arsenate of lead in the mixture and the large quantity of mixture applied. It has been noted above that in planning these experiments 300 gallons of liquid spray was to be applied per acre at each application, and 50 pounds of the dry mixture. This was not accomplished in practice. On the other hand, in operating the dusting machine so much material was lost while the engine was running badly that more than the quantity of dust specified was used before the operators were satisfied.

[5] According to the original plan, using 300 gallons of spray per acre and 50 pounds of dust, the cost per acre would have been $2.94 for lime-sulfur solution, $2.76 for the suspension sulfur, and $2.64 for the dust mixture.

TABLE 3. DATA ON TIME AND METHODS OF APPLICATION, CATCHPOLE ORCHARD, NORTH ROSE, NEW YORK

Date of application	Plat	Number of trees	Material used, and strength	Quantity used	Time required						Cost			Cost per tree
					Horse		Man		Machine		Labor	Material	Total cost	
					Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
May 3.	1	48	Lime-sulfur 1–33; lead arsenate 7 pounds–200 gallons	(Gals.) 190	2	...	2	...	1	...	$0.60	$2.00	$2.60	$0.054
May 14.	1	48	Lime-sulfur 1–33; lead arsenate 7 pounds–200 gallons	150	3	...	3	...	1	...	0.90	1.57	2.47	0.051
June 11.	1	48	Lime-sulfur 1–33; lead arsenate 7 pounds–200 gallons	160	2	09	2	09	0	43	0.65	1.68	2.33	0.049
Totals.	..	....	.....	500	7	09	7	09	2	43	$2.15	$5.25	$7.40	$0.154
May 3.	2	41	Dry sulfur and lead arsenate 4:1	(Lbs.) 140	2	...	2	...	1	...	$0.60	$ 7.40	$ 8.00	$0.195
May 14.	2	41	Dry sulfur and lead arsenate 4:1	76	1	32	1	32	0	46	0.45	4.01	4.46	0.109
June 11.	2	41	Dry sulfur and lead arsenate 4:1	85	0	54	0	54	0	27	0.30	4.48	4.78	0.117
Totals.	..	....	.....	301	4	26	4	26	2	13	$1.35	$15.89	$17.24	$0.421
May 3.	4	56	Paste sulfur 24; lead arsenate 3.5 lbs.–100 gals.	(Gals.) 200	2	...	2	...	1	...	$0.60	$1.84	$2.44	$0.044
May 14.	4	56	Paste sulfur 24; lead arsenate 3.5 lbs.–100 gals.	180	3	15	3	15	1	05	0.98	1.66	2.64	0.047
June 11.	4	56	Paste sulfur 24; lead arsenate 3.5 lbs.–100 gals.	185	2	30	2	30	0	50	0.75	1.70	2.45	0.044
Totals.	..	....	.....	565	7	45	7	45	2	55	$2.33	$5.20	$7.53	$0.135

It was thought more desirable for the present year to apply an amount sufficient to insure results if the mixture were effective at all. As will be shown later, the dust mixture was considerably more effective against insects than was the lime-sulfur and arsenate-of-lead mixture in every case; so that possibly a smaller quantity of lead might have been used. There is, therefore, good reason to believe that the cost of the dust applications may be reduced to the same amount as the cost of applying lime-sulfur as a liquid spray, if not lower. This will be the object of work during the coming year.

Weather records

No record was kept of weather conditions as they occurred in this orchard, with the exception of notes on a few of the rains that correspond with the record given below. However, the record (Table 4) of the Rochester branch of the United States Weather Bureau may be taken as indicating the principal periods during which infection occurred.

TABLE 4. TRANSCRIPT OF RECORDS TAKEN AT THE ROCHESTER STATION OF THE WEATHER BUREAU OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

Date	Precipitation (inches)	Weather conditions
April 27	.78	.....
April 28	.19	.....
May 15	T*	Cloudy
May 16	.02	Cloudy
May 17	0	Partly cloudy
May 18	.15	Partly cloudy
May 21	.06	Cloudy
May 22	.73	Cloudy
May 23	.04	Cloudy
May 24	T	Cloudy
May 25	T	Cloudy
May 27	.95	Cloudy
May 28	.64	Partly cloudy
May 31	T	Partly cloudy
June 1	.72	Partly cloudy
June 6	0	Cloudy
June 7	.22	Cloudy
June 8	0	Cloudy
June 19	.02	Cloudy
June 20	.12	Cloudy
June 21	0	Cloudy
June 25	.14	Clear
June 26	T	Cloudy
June 27	.86	Partly cloudy

* Trace; an amount less than .01 inch, too small to be measured.

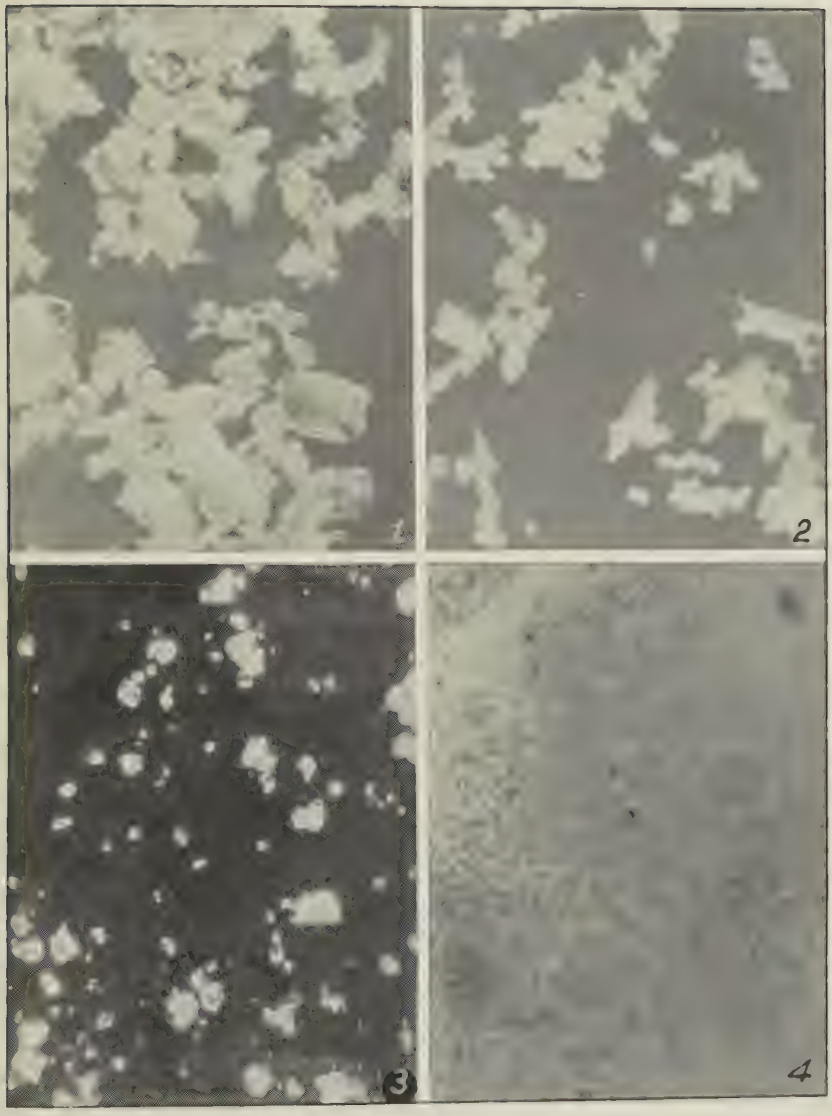

PLATE XIII.— *Various forms of sulfur*

FIG. 1.— *Ordinary flour sulfur*
FIG. 2.— *Ordinary flowers of sulfur used in experiments of 1912*
FIG. 3.— *Finely ground sulfur used in experiments of 1913*
FIG. 4.— *Sulfur precipitated by exposing lime-sulfur solution to the air*
All photomicrographs made with the same combination of lenses. In Figs. 1, 2, and 3 the photographs were made with reflected light, in FIG. 4 with transmitted light

That the first infection occurred during the rainy period from May 15 to May 18 is in accord with observations made in the orchard. The next prolonged infection period was clearly from May 21 to May 25, with two shorter periods near the end of the month. These dates constituted the principal scab-infection periods of the season.

Results of experiments

According to the original plans, the drops from the different plats were to be counted during the summer. Owing to a lack of rainfall of sufficient duration to permit infection from the time when the blossom clusters began to spread until two weeks after the blossoms were off, no pedicel infection occurred. The codling moth did not make its appearance until very late and then not in large numbers, so that there were very few drops due to attacks by this insect.[6]

An inspection of the orchard made on July 24 showed certainly that all the treatments had proved somewhat effective as compared with the check. Some counts were made, which showed about 15 per cent scab infection on the lime-sulfur-treated plat, about 25 per cent on the dusted plat, and 50 per cent on the check. Insect injuries were exceedingly abundant on the check plat but were much less on the treated plats.

The apples were picked and graded during the week of September 18 to 24. Four nonadjacent trees were selected from the inner protected area of each plat, from which the apples were picked, and a careful tabulation was made of the different injuries occurring on each apple and also on the apples picked up under the trees at that time. The apples from each lot of count trees, together with the apples from the remainder of each plat, were then separated into commercial grades by the same men who had picked the apples. The method of grading was the same as that employed in the other orchards owned by the same grower.

In making the tabulation the apples were first divided into sound and unsound. The unsound apples were further classified, each individual apple falling under one to five headings, depending on whether or not it was affected with scab, whether or not spring caterpillars had attacked it, whether or not codling moth had entered at the side or at the end, and whether or not curculio had punctured it.

Each apple showing any trace of scab, even though only a small spot near the calyx end, was listed as scabby. Each apple bearing innumerable scab spots likewise was counted as only one in the tabulation. While this is by no means a fair way of determining the relative amount of scab, yet it did not seem practicable to count each individual spot.

[6] The majority of the drops for the season, therefore, are included in Table 6, since the excessively dry summer prevented them from rotting.

TABLE 5. A CLASSIFICATION OF THE PICKED RHODE ISLAND GREENING APPLES FROM THE CATCHPOLE ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Bud moth and other spring caterpillars		Codling moth		Codling moth				Curculio	
												Side entrance		Calyx entrance			
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Unsprayed	1,581	56	3.5	1,525	96.5	1,373	86.8	733	46.4	242	15.3	190	12.0	112	7.1	44	2.78
	1,445	188	13.0	1,257	87.0	963	66.6	598	41.4	145	10.0	117	8.1	58	4.0	76	5.26
	1,613	58	3.6	1,555	96.4	1,442	89.4	572	35.5	257	15.9	233	14.4	126	7.8	74	4.59
	1,724	172	10.0	1,552	90.0	1,315	76.3	593	34.4	138	8.0	105	6.1	68	3.9	59	3.42
Total	6,363																
Average			**7.5**		**92.5**		**79.8**		**39.4**		**12.3**		**10.2**		**5.7**		**4.01**
Probable error			±1.38		±1.38		±3.04		±1.6		±1.14		±1.1		±0.68		±0.317
Suspension of sulfur and lead arsenate	3,254	2,019	62.0	1,235	38.0	1,045	32.1	268	8.2	13	0.4	10	0.3	1	0.03	16	0.49
	1,434	970	67.6	464	32.4	381	26.6	137	9.6	6	0.4	9	0.6	1	0.07	6	0.42
	3,157	2,046	64.8	1,111	35.2	983	31.1	205	6.5	17	0.5	21	0.7	1	0.03	5	0.16
	3,528	2,141	60.7	1,387	39.3	1,206	34.2	331	9.4	35	1.0	43	1.2	2	0.06	16	0.45
Total	11,373																
Average			**63.8**		**36.2**		**31.0**		**8.4**		**0.6**		**0.7**		**0.05**		**0.38**
Probable error			±0.889		±0.889		±0.94		±0.414		±0.08		±1.09		±0.0056		±0.04
Lime-sulfur and lead arsenate	1,383	598	43.2	785	56.8	493	35.6	453	32.8	33	2.4	35	2.5	3	0.22	10	0.72
	2,493	1,499	60.1	994	39.9	697	28.0	472	18.9	26	1.0	25	1.0	4	0.16	4	0.16
	2,504	1,951	77.9	553	22.1	218	8.7	352	14.1	25	1.0	33	1.3	1	0.04	10	0.40
	2,484	1,564	63.0	920	37.0	287	11.6	696	28.0	26	1.0	30	1.2	2	0.08	16	0.64
Total	8,864																
Average			**61.0**		**39.0**		**21.0**		**23.5**		**1.4**		**1.5**		**0.13**		**0.48**
Probable error			±4.16		±4.16		±3.78		±2.48		±0.198		±0.2		±0.02		±0.07
Dry sulfur and lead arsenate	2,529	1,949	77.1	580	22.9	512	20.2	86	3.4	10	0.4	11	0.4	0	0	4	0.16
	3,117	1,694	54.3	1,423	45.7	1,346	43.2	135	4.3	10	0.3	11	0.4	0	0	1	0.03
	1,816	1,158	63.8	658	36.2	601	33.1	88	4.8	12	0.7	13	0.7	0	0	5	0.28
	3,538	2,100	59.4	1,438	40.6	1,320	37.3	170	4.8	8	0.2	10	0.3	0	0	3	0.08
Total	11,000																
Average			**63.7**		**36.3**		**33.5**		**4.3**		**0.4**		**0.5**		**0.**		**0.14**
Probable error			±2.85		±2.85		±2.8		±0.196		±0.17		±0.05		±0		±0.03

TABLE 6. A CLASSIFICATION OF THE DROP APPLES PICKED UP AT HARVEST TIME FROM THE CATCHPOLE ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Bud moth and other spring caterpillars		Codling moth		Codling moth				Curculio	
												Side entrance		Calyx entrance			
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Unsprayed	219	12	5.5	207	94.5	167	76.3	85	38.8	31	14.2	37	16.9	8	3.7	6	2.7
	275	52	18.9	223	81.1	163	59.3	92	33.5	21	7.6	17	6.2	10	3.6	18	6.5
	277	12	4.3	265	95.7	239	86.3	72	26.0	73	26.4	82	29.6	33	11.9	10	3.6
	249	36	14.5	213	85.5	157	63.1	78	31.3	37	14.9	23	9.2	20	8.0	14	5.6
Total	1,020		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**10.8**		**89.2**		**71.3**		**32.4**		**15.8**		**15.5**		**6.8**		**4.6**
Probable error	.....		±2.06		±2.06		±2.58		±1.3		±2.2		±3.07		±1.2		±0.5
Suspension of sulfur and lead arsenate	256	157	61.3	99	38.7	63	24.6	38	14.8	12	4.7	12	4.7	1	0.4	3	1.2
	167	92	55.1	75	44.9	43	25.7	29	17.4	18	10.8	19	11.4	0	0	0	0
	75	27	36.0	48	64.0	31	41.3	22	29.3	14	18.7	15	20.0	0	0	2	2.7
Total	498		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**50.8**		**49.2**		**30.5**		**20.5**		**11.4**		**12.0**		**0.1**		**1.3**
Probable error	.....		±4.2		±4.2		±3.0		±2.46		±2.2		±2.44		±0.07		±0.4
Lime-sulfur and lead arsenate	291	93	32.0	198	68.0	107	36.8	117	40.2	18	6.2	20	6.9	1	0.3	3	1.0
	254	157	61.8	97	38.2	71	28.0	36	14.2	12	4.7	12	4.7	1	0.4	0	0
	150	107	71.3	43	28.7	10	6.7	34	22.7	5	3.3	5	3.3	0	0	1	0.7
	251	122	48.6	129	51.4	22	8.8	109	43.4	16	6.4	16	6.4	1	0.4	0	0
Total	946		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**53.4**		**46.6**		**20.1**		**30.1**		**5.2**		**5.3**		**0.3**		**0.4**
Probable error	.....		±5.0		±5.0		±4.3		±3.68		±0.35		±0.47		±0.056		±0.15
Dry sulfur and lead arsenate	139	98	70.5	41	29.5	27	19.4	15	10.8	4	2.9	4	2.9	1	0.7	0	0
	174	85	48.9	89	51.1	71	40.8	30	17.2	4	2.3	4	2.3	0	0	0	0
Total	313		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**59.7**		**40.3**		**30.1**		**14.0**		**2.6**		**2.6**		**0.4**		**0**
Probable error	.....		±5.17		±5.17		±5.09		±1.54		±0.14		±0.14		±0.19		±0

Among the spring caterpillars, bud moth was by far the most troublesome; green fruit worms, green leaf rollers, and others, however, were also present.

In tabulating the injuries caused by the codling moth the total number of affected apples is listed, followed by the actual number of larvæ entering at the side of the apple.

Since the apples were only slightly affected by curculio, no account was taken as to whether there was one mark or several marks on each apple.

In order to show the relative value of the different materials used as insecticides and fungicides, the percentages of the apples from each tree affected with each of the various insects and with apple scab have been computed, together with the average, or mean, of these figures and the probable error[7] of the mean.

Scab control.— From tables 5 and 6 it may be seen that all three treatments used reduced the amount of scab decidedly below the amount on the untreated plat. The difference between the average of the check and the average of each of the sprayed plats, with a probable error of ± 3 per cent, shows plainly that all the mixtures applied had a very decided fungicidal action. The difference between the suspension of sulfur and sulfur applied as a dust is so slight as to be negligible, since it is smaller than the probable error. The lime-sulfur plat shows the lowest average percentage of scab, but its superiority in this respect is not very certain because of the large variation in the amount of scab on the different trees. The probable error is large and would indicate that there is an even chance that the true mean would lie between 16 and 25 per cent. The indications are, then, that the lime-sulfur is slightly superior as a fungicide, but this is not entirely certain.

In the table showing the percentages of drop apples, exactly the same differences may be pointed out except that here the variation between the different trees and the probable error are even greater. The sprayed plats, however, all show a decided control of scab as compared with the unsprayed plat.

It should not be understood that in any of the sprayed plats a remarkably good control of scab was secured; but this does not make less valuable the comparison between the different materials used. The somewhat high percentage of scabby apples in all sprayed plats is attributed rather to the fact that the third application of spray was delayed because of the late emergence of the codling moth, than to poor action of the materials used. Since this was the period during which most of the apple-

[7] The probable error added to and subtracted from the mean gives the limits between which it is an even chance that the true mean lies. There is also an even chance that the true mean lies outside of this range. It is improbable, however, that an error will be many times as large as the probable error.

scab infection took place this summer, another application made in the interval between the second and the third application would undoubtedly have been very valuable.

Insect control.— It may be seen from the tables that the insects causing most injury to the apples in this orchard this year were those classified under the head of "Bud moth and other spring caterpillars"; these include leaf-rollers, green fruit worms, and others. The figures indicate that in the unsprayed block the true average would be between 38 and 41 per cent of picked apples injured by these insects. On the unsprayed block only about 12 per cent of the picked apples were injured by codling moth, and 4 per cent by curculio. It will be noticed that the best control of each of these insects was secured on the dusted plat. It is difficult to understand why there should have been so large a difference in insect control between arsenate of lead applied with lime-sulfur and that applied with suspension of sulfur.

The counts from the drops of this block confirm the results obtained from the counts of the picked apples. There is a higher percentage of injuries on the drops, which of course was to be expected. The dusted apples appear the best throughout with respect to insect control, with the possible exception of those in which codling moth larvæ entered the calyx; in that case, however, the probable error is so large in comparison with the difference in percentages between the various mixtures as to render worthless any comparison based on these figures.

Sound and unsound fruit.— From the figures in the tables it may be seen that in total percentages of sound and unsound picked apples there was no dependable difference between the various mixtures used. The averages are slightly against the lime-sulfur spray; but the difference in each case is less than the probable error, so that it is of no importance. All the sprayed plats had about 56 per cent more sound apples than the unsprayed plat had.

These figures are reflected in the commercial grading so far as it is available. Due to a misunderstanding, the record of the commercial yield of the lime-sulfur plat was partially lost and unfortunately it cannot be included here.

The graders, without knowing of the different treatments, stated that the apples from the dusted block looked better on the table and packed a higher percentage of No. 1 apples. This may be attributed to the more effective insect control — since the percentage of scab was actually higher than in the apples receiving liquid spray — and to the fact that minute scab spots were overlooked by the packers.

The apples from the check block were of evaporator-stock quality, but on a rising market they were disposed of in barrels at a considerably reduced price.

Experiments in Lawson orchard at Owego

This orchard is located about four miles north of Owego and about two miles from Flemingville. The orchard is situated so that it slopes gently toward the east. It is twenty years old and has been in sod for a number of years; it was not cultivated this year, but hogs were allowed to run in it during the summer. The trees were generally in good condition, with little deadwood, although they were not making much growth. The orchard had never been sprayed. The year before it had borne a good crop of apples which were very scabby. Ben Davis apples kept until spring and examined by the writer in March were nearly all scabby, and some were almost covered with scab spots.

Enough fruit buds were present to give a prospect for a fair set of fruit; comparatively little fruit set, however, probably due to the frosts and the cold weather at blossoming time — the temperature being 26° F. one night during blossoming. The experiments were first outlined so as to include a block of Northern Spy and a block of Ben Davis apples. The experiments in the Ben Davis block were later altered so as to omit some of the Ben Davis apples, owing to a poor prospect for fruit, and to include some Tompkins Kings. It will be seen from the charts (Figs. 19 and 20) that this experiment was planned on a large scale, the plats being large enough to leave, in most cases, two rows through the center from which to select count trees.

Methods and materials used

The dusting machine employed here was like that used in the Catchpole orchard. While a 1½-power engine was said to be sufficient to run one of these machines, it proved to be rather too light to do satisfactory work. The engine was working so near its capacity that if for any reason it missed a stroke or two it stopped; also, since it was carrying about the maximum load, there was a tendency for it to heat rapidly. It was difficult to obtain data as to the time required for dusting the trees, because of this frequent difficulty with the engine.

The liquid-spray machine used was a small power apparatus fitted up by the grower, and worked satisfactorily. The spraying was all done from the ground with 10-foot spray rods. This was fairly satisfactory, since the trees were comparatively small and headed low.

In performing this experiment various difficulties were met with which led to deviations from the original plan of execution and to rather poor results; these will be given for what they are worth, since they are of value in comparing the different methods quite as much as though better results had been obtained. In the first place, the liquid spray machine was not ready in time for the first application on the Ben Davis and

Tompkins King block; but, owing to the fact that the Northern Spies were later, the first application was made on those. The Tompkins King and the Ben Davis apples, therefore, received the application just as the blossoms were falling and another application about four weeks later. The Northern Spies received an application just before the blossoms opened and one as the petals were falling. When the time arrived for the third application it was omitted, because there were not enough apples on the trees to make it worth while. While this was undoubtedly true from a commercial standpoint, yet there was rather more fruit set on the trees than was thought; the fruit had been hidden by the dense foliage which characterizes this variety, so that it was thought worth while to pick and examine the apples in order to get some knowledge of the comparative value of the mixtures applied.

By reference to the map of this orchard (Figs. 19 and 20) it will be seen that two separate sets of plats to be sprayed were laid out, one including

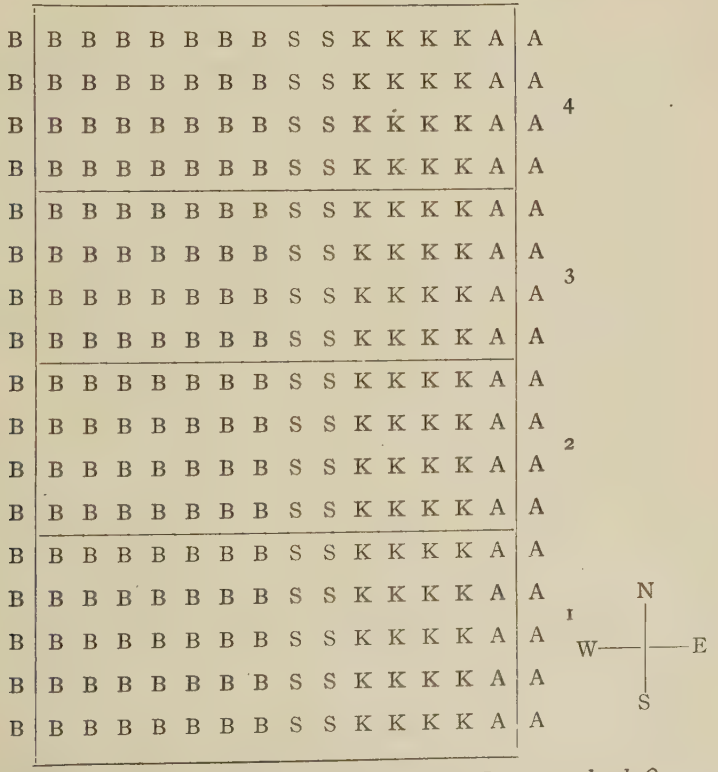

FIG. 19.— *Chart showing plan of the experiment performed in the Lawson orchard, Owego, New York. The trees enclosed in the black line represent the different plats: 1, dusted; 2, sprayed with lime-sulfur solution; 3, sprayed with suspension sulfur; 4, untreated. A, Pewaukee; B, Ben Davis; S, Northern Spy; K, Tompkins King*

1				2				3			4			
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	O	S	S	S	O	S	S	S	O	S
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S	S	S	S	S	S	S	O	S	S	S	S	S	S	S
S	S	S	P	S	S	S	S	S	S	O	S	S	S	S
S	S	S	O	P	P	P	P	S	S	S	S	S	S	S
S	S	S	S	S	O	O	S	S	S	S	P	S	S	S
S	S	S	S	S	S	S	S	S	S	S	S	S	O	S
S	S	S	O	S	S	O	S	S	S	S	O	S	S	S
S	S	S	S	S	S	O	S	S	S	P	S	S	S	S

FIG. 20.— *Chart showing plan of the experiment performed in the Lawson orchard, Owego, New York. The trees enclosed in the black lines represent the different plats: 1, sprayed with lime-sulfur; 2, sprayed with suspension sulfur; 3, untreated; 4, dusted. S, Northern Spy; O, missing trees; P, poor trees*

the Ben Davis and the Tompkins King apples and the other the Northern Spies. The data for the quantities of material applied and the cost for these two sets of plats are given separately; those for the Tompkins King and the Ben Davis are given together. Thus, while the quantity of spray material and the costs were based on this entire block, the Tompkins King apples only were picked and examined. The data for the block of Ben Davis and Tompkins King apples are given in Table 7.

Weather records

A record of the temperature and the rainfall at this farm during the summer was made by Mr. Lawson. The data given in Table 8 are copied from that record.

The first infection probably took place at about the same time as in the Catchpole orchard, namely, from May 16 to May 18, since the first scab spots became apparent on the foliage at about the same time. There was also an infection period from May 22 to May 27 when further infections undoubtedly occurred.

Results of experiments, Tompkins King apples

In the first block of apples careful counts were made only of the Tompkins Kings. The apples on the trees from which careful counts were made were picked on October 3 and the commercial sorting was completed on

TABLE 7.— DATA ON TIME AND METHODS OF APPLICATION, TOMPKINS KING AND BEN DAVIS APPLES, LAWSON ORCHARD, OWEGO, NEW YORK

Date of application	Number of trees	Material used, and strength	Quantity used	Time required						Cost			Cost per tree
				Horse		Man		Machine		Labor	Material	Total cost	
				Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
May 15..	56	Lime-sulfur 1–40; lead arsenate 3.5 pounds–100 gallons.....	(Gals.) 150	3	15	4	57	1	39	$1.32	$1.47	$2.79	$0.050
June 12..	56	Lime-sulfur 1–40; lead arsenate 3.5 pounds–100 gallons.....	150	4	00	6	00	2	00	1.60	1.47	3.07	0.055
Totals..	....	.....	300	7	15	10	57	3	39	$2.92	$2.94	$5.86	$0.105
May 15..	56	Dry sulfur and arsenate of lead 4:1.....	(Lbs.) 96	1	00	1	00	0	30	$0.30	$5.07	$5.37	$0.096
June 13..	56	Dry sulfur and arsenate of lead 4:1.....	75	1	10	1	10	0	35	0.35	3.96	4.31	0.077
Totals..	....	.....	171	2	10	2	10	1	5	$0.65	$9.03	$9.68	$0.173
May 15..	56	Paste sulfur 24; lead arsenate 3.5 pounds–100 gallons.....	(Gals.) 150	2	56	4	24	1	28	$1.17	$1.38	$2.55	$0.045
June 12..	56	Paste sulfur 24; lead arsenate 3.5 pounds–100 gallons.....	150	3	30	5	15	1	45	1.40	1.38	2.78	0.050
Totals..	....	.....	300	6	26	9	39	3	13	$2.57	$2.76	$5.33	$0.095

October 8. The yield on these trees was very light, due to the frosts in the spring which prevented a good set of fruit. On the unsprayed plat, especially, there was very little fruit, much less than on any of the other plats. This scarcity of fruit was apparently brought about by various insects. On some of the trees the apple-tree tent-caterpillar worked so much damage as to leave practically no apples. The counts of apples on the unsprayed plat are practically of no value because of the few apples on which they are based. While there were comparatively few apples on all the plats, it seems fairly certain that the difference in number of

TABLE 8. TRANSCRIPT FROM WEATHER RECORD AT LAWSON FARM

Date	Duration of rainfall	Precipitation (inches)
May 6	4 to 7 p. m.	.040
May 9	6 to 7 a. m.	.045
May 16	7 a. m.	.030
May 18	7 a. m. to 2 p. m.	.013
May 22 / May 23	7 a. m. May 22 to 12 p. m. May 23	1.620
May 25		.170
May 27	8 p. m. to 12 m.	1.040
June 1		.060
June 7		.020
June 20	4 to 6 p. m.	.510
June 27	5 to 7 a. m.	.490
July 9	All day	.860
July 26		1.660

apples between the unsprayed plat and the plats adjoining it was due principally to the effect of the spray mixture applied.

Although the unsprayed plat of this block of trees yielded so few apples as to be worthless as a check, the percentages of apples injured by various insects are given as being of some value as a comparison, especially since they agree in a general way with the results obtained in the Catchpole orchard. Of course it must be remembered that in this block of trees the first application was omitted because the apparatus was not ready in time. The control was therefore not nearly so good as it would have been if more applications had been made; but the comparison between the different materials should be almost, if not quite, as good as though better control had been secured. In fact, it has not infrequently happened that when several different materials were applied, practically perfect control was secured in all cases; so that one is led to believe that the conditions were not strenuous enough to really test the materials.

The following tables show the percentages of apples injured by various insects and by apple scab as computed from the above experiments, with the averages for the different plats:

TABLE 9. A CLASSIFICATION OF THE PICKED TOMPKINS KING APPLES FROM THE LAWSON ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Bud moth and other spring caterpillars		Codling moth		Codling moth				Curculio	
												Side entrance		Calyx entrance			
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Unsprayed[8]	64	7	10.9	57	89.1	14	21.9	53	82.8	13	20.3	8	12.5	7	10.9	1	1.6
Suspension of sulfur and lead arsenate	385	194	50.4	191	49.6	101	26.2	108	28.1	16	4.2	19	4.9	0	0	8	2.1
	198	72	36.4	126	63.6	60	30.3	78	39.4	11	5.6	10	5.1	2	1.0	3	1.5
	230[9]	110	47.8	120	52.2	23	10.0	89	38.7	26	11.3	28	12.2	0	0	2	0.9
Total	813		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**44.9**		**55.1**		**22.2**		**35.4**		**7.0**		**7.4**		**0.3**		**1.5**
Probable error	.....		±2.4		±2.4		±2.9		±2.0		±0.615		±0.678		±0.17		±0.19
Lime-sulfur and lead arsenate	150	65	43.3	85	56.7	52	34.7	38	25.3	19	12.7	23	15.3	2	1.3	7	4.7
	129	65	50.4	64	49.6	22	17.1	44	34.1	7	5.4	8	6.2	0	0	0	0
	408	124	30.4	284	69.6	113	27.7	210	51.5	27	6.6	31	7.6	0	0	21	5.1
	100	47	47.0	53	53.0	20	20.0	46	46.0	2	2.0	1	1.0	1	1.0	3	3.0
Total	787		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**42.8**		**57.2**		**24.9**		**39.2**		**6.7**		**7.5**		**0.6**		**3.2**
Probable error	.....		±2.55		±2.55		±2.3		±3.4		±0.3		±1.7		±0.2		±0.7
Dry sulfur and lead arsenate	494	207	41.9	287	58.1	222	44.9	108	21.9	15	3.0	17	3.4	1	0.2	10	2.0
	554	284	51.3	270	48.7	155	28.0	122	22.0	27	4.9	31	5.6	1	0.2	18	3.2
	754	339	45.0	415	55.0	216	28.6	228	30.2	33	4.4	32	4.2	1	0.1	10	1.3
	250	111	44.4	139	55.6	95	38.0	57	22.8	11	4.4	12	4.8	0	0	3	1.2
Total	2,052		.....		.....		.....		.....		.....		.....		.....		.....
Average	.....		**45.7**		**54.3**		**34.9**		**24.2**		**4.2**		**4.5**		**0.1**		**1.9**
Probable error	.....		±1.2		±1.2		±2.2		±1.2		±0.23		±0.08		±0.02		±0.3

[8] All of the two inner of the unsprayed rows of trees, eight trees all together, are included in this tabulation as one tree.
[9] Three trees were picked together in this plot, from which these figures were taken.

TABLE 10. A CLASSIFICATION OF THE DROP APPLES PICKED UP AT HARVEST TIME FROM THE LAWSON ORCHARD

Treatment	Total number of apples	Sound		Unsound		Apple scab		Bud moth and other spring caterpillars		Codling moth		Codling moth				Curculio	
												Side entrance		Calyx entrance			
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Unsprayed[8]	6	0	0	6	100.0	2	33.3	4	66.7	2	33.3	2	33.3	1	16.7	0	0
Suspension of sulfur and lead arsenate	59	23	39.0	36	61.0	13	22.0	26	44.1	7	11.9	8	13.6	0	0	2	3.4
	22[9]	5	22.7	17	77.3	4	18.2	14	63.6	3	13.6	3	13.6	0	0	0	0
	17[9]	4	23.5	13	76.5	3	17.6	10	58.8	3	17.6	4	23.5	0	0	1	5.9
Total	98																
Average			**28.4**		**71.6**		**19.3**		**55.5**		**14.4**		**16.9**		**0**		**3.1**
Probable error			±2.5		±2.5		±0.89		±3.3		±0.93		±1.7		±0		±0.94
Lime-sulfur and lead arsenate	38	11	28.9	27	71.1	11	28.9	17	44.7	9	23.7	10	26.3	0	0	1	2.6
	7	3	42.9	4	57.1	0	0	3	42.9	2	28.6	3	42.9	0	0	0	0
	70	24	34.3	46	65.7	22	31.4	26	37.1	5	7.1	5	7.1	0	0	0	0
	13	1	7.7	12	92.3	4	30.8	7	53.8	4	30.8	4	30.8	0	0	0	0
Total	128																
Average			**28.5**		**71.5**		**22.8**		**44.6**		**22.6**		**26.8**		**0**		**0.7**
Probable error			±8.7		±8.7		±4.5		±2.0		±3.1		±4.3		±0		±0.38
Dry sulfur and lead arsenate	33	9	27.3	24	72.7	18	54.5	9	27.3	3	9.1	3	9.1	0	0	3	9.1
	26	8	30.8	18	69.2	9	34.6	8	30.8	3	11.5	3	11.5	0	0	0	0
	42	16	38.1	26	61.9	19	45.2	11	26.2	2	4.8	3	7.1	0	0	0	0
	14	6	42.9	8	57.1	5	35.7	1	7.1	3	21.4	2	14.3	1	7.1	0	0
Total	115																
Average			**34.8**		**65.2**		**42.5**		**22.9**		**11.7**		**10.5**		**1.8**		**2.3**
Probable error			±1.9		±1.9		±2.7		±3.1		±2.55		±0.9		±1.0		±1.3

[8] All of the two inner of the unsprayed rows of trees, eight trees all together, are included in this tabulation as one tree.
[9] Three trees were picked together in this plot, from which these figures were taken.

It will be noticed that in the above results the relative control of the various pests was much like that in the Catchpole experiment, although poorer on the whole — as should be expected from two sprayings instead of three. This is particularly noticeable in the control of insects. In this experiment the application of arsenate of lead with the lime-sulfur solution and with the suspension of sulfur yielded results more nearly alike, as should be expected, than were obtained in the previous experiment. Better control of insects was secured in this experiment with the dust than with liquid spray, but poorer control of apple scab as in the experiment previously described.

The result of the counts of drops is liable to considerable error because of the small number of drops; but here again, in a general way, the figures affirm the statements previously made, although the dropped apples were naturally more infested than were the picked apples.

Commercial grading.— These apples were sorted by the grower, as in the previous case, and an account was kept of the different grades except on the unsprayed plat where altogether there was only a half barrel of very poor apples. The results of the commercial sorting are given in the following table:

TABLE 11. COMMERCIAL GRADING OF PICKED TOMPKINS KING APPLES FROM THE LAWSON ORCHARD

Treatment	Number of trees	Total yield (barrels)	No. 1 apples		No. 2 apples		No. 3 apples		Yield per tree (barrels)
			Barrels	Percentage	Barrels	Percentage	Barrels	Percentage	
Unsprayed	19	0.66	.....	.....	.....	.....	.....	.....	0.04
Suspension sulfur	15	4.72	3.00	63.5	1.50	31.8	.22	4.7	0.32
Lime-sulfur	13	8.06	5.50	68.2	2.00	24.8	.56	7.0	0.62
Dry sulfur	15	12.16	9.00	74.0	2.66	21.9	.50	4.1	0.81

In this experiment, also, the better insect control apparently more than made up for the poorer control of scab, so that the dusted apples graded better commercially than those sprayed with the liquid.

Experiments in the Northern Spy orchard

Although the third spray was omitted on this block because so few apples had set, it was thought worth while to make some record of the comparative results, since at the time of picking the Tompkins Kings there seemed to be nearly as many apples on the Northern Spy trees.

TABLE 12. DATA ON TIME AND METHODS OF APPLICATION, NORTHERN SPY APPLES, LAWSON ORCHARD, OWEGO, NEW YORK

Date of application	Number of trees	Material used, and strength	Quantity used	Time required						Cost			Cost per tree
				Horse		Man		Machine		Labor	Material	Total cost	
				Hrs.	Min.	Hrs.	Min.	Hrs.	Min.				
May 6..	41	Lime-sulfur 1–40; lead arsenate 3.5 pounds–100 gallons.....	(Gals.) 90	2	20	3	30	1	10	$0.93	$0.88	$1.81	$0.044
May 13..	41	Lime-sulfur 1–40; lead arsenate 3.5 pounds–100 gallons.....	80	2	00	3	00	1	00	0.80	0.78	1.58	0.039
Totals..	....	.....	170	4	20	6	30	2	10	$1.73	$1.66	$3.39	$0.083
May 6 and 7.....	40	Dry sulfur and arsenate of lead 4:1.....	(Lbs.) 80	1	04	1	04	0	32	$0.32	$4.22	$4.54	$0.114
May 15..	40	Dry sulfur and arsenate of lead 4:1.....	76	0	46	0	46	0	23	0.23	4.01	4.24	0.106
Totals..	....	.....	156	1	50	1	50	0	55	$0.55	$8.23	$8.78	$0.220
May 6 and 7.....	34	Paste sulfur 24; lead arsenate 3.5 pounds–100 gallons.....	(Gals.) 100	3	00	4	30	1	30	$1.20	$0.92	$2.12	$0.062
May 15..	34	Paste sulfur 24; lead arsenate 3.5 pounds–100 gallons.....	80	2	18	3	27	1	09	0.92	0.74	1.66	0.049
Totals..	....	.....	180	5	18	7	57	2	39	$2.12	$1.66	$3.78	$0.111

In this block the apples on the unsprayed plat had remained longer on the trees, the fruit of this variety being less likely to be blown off from the trees than that of other varieties because of the long, flexible stems. The data on cost and methods of application for the Northern Spy apples are given in Table 12.

Through a misunderstanding all the apples on each plat in the Northern Spy orchard had been picked and placed together, so that counts from individual trees could not be made separately. The figures for the separate trees, therefore, cannot be given, nor the probable error determined on that basis. The probable error appears to be no greater, and appears to be even less in most cases, than in records from the Tompkins King apples, judging records for crates tabulated separately. Also, the number of apples examined in this case was nearly twice as large as in the case of the Tompkins King apples. It must be remembered in connection with these figures that the third application was not made; and this is noticeable in the very much higher percentage of apples injured by the late brood of codling moths, that is, the larvæ entering the sides of the apples. In fact, the sprays applied can scarcely be said to have had any effect on these insects. There was very little or no scab-infection weather after the third application, so that the results on scab control should be fairly comparable with those in the case of the Tompkins King apples.

The drops on these plats were so few as not to give any reliable data. On the lime-sulfur plat only seventy-nine apples were picked up at picking time, which number does not give a fair basis for comparison.

The number of apples counted and the number falling in each class, with percentages of each, are given in Table 13.

As stated above, the lack of the third spray is clearly apparent in these results in the large amount of injury done by codling-moth larvæ entering the sides of the apples and in the poor curculio control. It may safely be said that the figures on curculio do not fully represent the difference between the sprayed and the unsprayed plat; because as a rule the apples injured by curculio on the check plat frequently showed the effects of numerous punctures, so that they were almost wholly misshapen, while those on the sprayed plat recorded as affected by curculio usually had not more than a single puncture, or possibly two punctures, causing russeted patches to appear on the apples.

In the control of bud moth, leaf-rollers, and the green fruit worm, and the codling moth entering the calyx end of the apple, the results are clearly in accord with the experiments previously described. The dust mixture as applied was superior to the liquid sprays.

The apples sprayed with lime-sulfur solution in this experiment showed 39.8 per cent of scabby apples as compared with 25.8 per cent for those

TABLE 13. A CLASSIFICATION OF THE PICKED NORTHERN SPY APPLES FROM THE LAWSON ORCHARD, OWEGO, NEW YORK

Treatment	Total number of apples	Sound		Unsound		Apple scab		Bud moth and other spring caterpillars		Codling moth		Codling moth				Curculio	
												Side entrance		Calyx entrance			
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Untreated	914	84	9.2	830	90.8	459	50.2	214	23.4	420	46.0	476	52.1	70	7.7	293	32.1
Suspension of sulfur and lead arsenate	912	267	29.3	645	70.7	211	23.1	147	16.1	357	39.1	411	45.1	30	3.3	44	4.8
Lime-sulfur and lead arsenate	420	93	22.1	327	77.9	167	39.8	79	18.8	176	41.9	257	61.2	12	2.9	20	4.8
Dry sulfur and lead arsenate	4,429	1,689	38.1	2,740	61.9	1,143	25.8	303	6.8	1,211	27.3	1,412	31.9	85	1.9	652	14.7

dusted. The error here in the average for the dusted plat does not appear very large, judging from the percentage of scabby apples in the lots tabulated separately. There may be a larger error in the average for the check plat, as a fewer number of apples were considered here.

In this experiment it is also noticeable that the percentage of sound apples was largest on the dusted plat, which seemed to be the tendency in the other dusted plats although not quite so marked as here.

GENERAL SUMMARY AND CONCLUSIONS

No attempt has been made to use the dust mixture as a dormant treatment, and it is rather improbable that it would prove effective against San José scale.

All previous reports from experiment stations of the efficacy of dusting for apple scab have been negative. The essential fungicidal agent in previous tests has been copper.

The use of finely ground sulfur as the fungicide in a dust mixture has given very encouraging results and warrants further trials on a more extensive scale.

The application of arsenate of lead in powdered form in the quantities applied is more effective against the common orchard insects that chew than is the same substance applied wet.

The cost of material and application of the dust mixture used this year is as great as, or greater than, the application of a wet spray.

The time required for dusting an orchard is much less than that required for spraying it.

The orchardist with additional acreage coming into bearing can probably afford to await the results of another year of experimentation before buying additional equipment.

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